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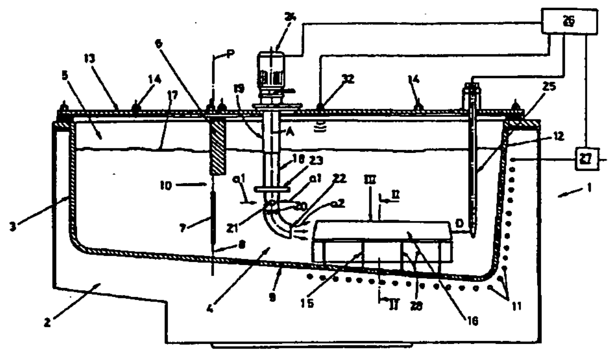
(54) METHODE ET APPAREIL POUR FONDRE UN METAL
(54) METHOD AND APPARATUS FOR MELTING A METAL

(57)

In a method of melting metal of a predetermined liquidus temperature, particularly a non-iron metal, such as magnesium, in a heated melting chamber into which solid metal is introduced and where a stream is generated, the parameters of flow are chosen such that the melting time is, in maximum, half the melting time without this stream under the condition that the temperature of the molten metal, when measured at at least one place in a distance of 5 mm in maximum from the solid metal, does not fall below liquidus temperature. To this end, an apparatus may be provided comprising at least one pump in a melting chamber having an associated heating device. This pump sucks the melt through at least one inlet opening and discharges the melt through at least one outlet opening. Both inlet opening and outlet opening are arranged within the melt bath of the melting chamber.



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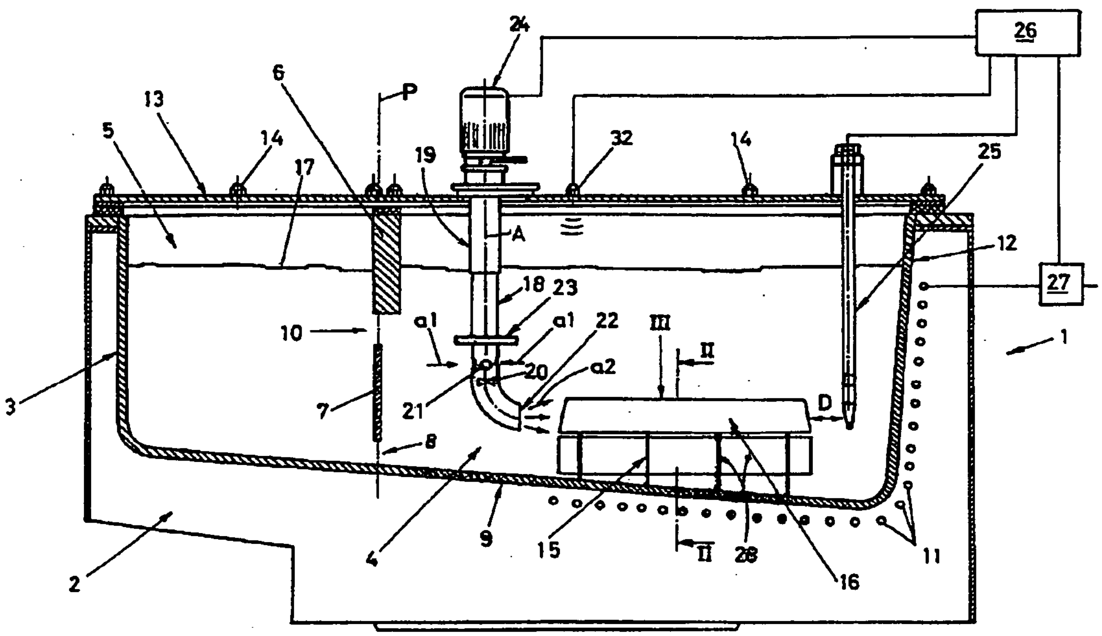

(57) Abrégé/Abstract:

In a method of melting metal of a predetermined liquidus temperature, particularly a non-iron metal, such as magnesium, in a heated melting chamber into which solid metal is introduced and where a stream is generated, the parameters of flow are chosen such that the melting time is, in maximum, half the melting time without this stream under the condition that the temperature of the molten metal, when measured at at least one place in a distance of 5 mm in maximum from the solid metal, does not fall below liquidus temperature. To this end, an apparatus may be provided comprising at least one pump in a melting chamber having an associated heating device. This pump sucks the melt through at least one inlet opening and discharges the melt through at least one outlet opening. Both inlet opening and outlet opening are arranged within the melt bath of the melting chamber.

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Abstract of the disclosure

In a method of melting metal of a predetermined liquidus temperature, particularly a non-iron metal, such as magnesium, in a heated melting chamber into which solid metal is introduced and where a stream is generated, the parameters of flow are chosen such that the melting time is, in maximum, half the melting time without this stream under the condition that the temperature of the molten metal, when measured at at least one place in a distance of 5 mm in maximum from the solid metal, does not fall below liquidus temperature. To this end, an apparatus may be provided comprising at least one pump in a melting chamber having an associated heating device. This pump sucks the melt through at least one inlet opening and discharges the melt through at least one outlet opening. Both inlet opening and outlet opening are arranged within the melt bath of the melting chamber.

(Fig. 1)

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METHOD AND APPARATUS FOR MELTING A METAL

Field of the invention

The present invention relates to a method of melting metal, particularly a non-iron metal, such as magnesium of a predetermined liquidus temperature in a heated melting chamber having a bottom, wherein solid metal is introduced, and wherein a stream is generated within the melt. If, in the context of the present invention, it is spoken of a "metal", this term should also concern alloys of any kind.

Background of the invention

Generating a stream of molten metal in a melting chamber according to the prior art is effected to various purposes. For example, WO 99/48637 provides an agitator for avoiding gravitational segregation. Although there was a "sluice" having a heating device for its own within the melting chamber and which was closed by a filter, but, of course, the stream had no influence to the interior of this closed recipient.

The construction according to DE-A-195 04 415 has also an agitator which, however, serves to inject an inert gas into the melt through its hollow shaft, to distribute this inert gas within the melt, thus driving oxides and other swimming matters to the surface level of the bath of molten metal.

In both cases, as above, the agitators are far enough from the solid metal to be molten in order to allow effective agitating the melt of a small viscosity at all (as will be explained later on with reference to the recognition on which the invention is based) which is far from the solid metal. It is clear that such agitators will also make the temperature of the bath more uniform even with excessive temperatures.

Pumps have also been incorporated into a melting chamber (e.g. US-A-5,411,240), but they served to the purpose of con-

veying the melt from the melting chamber into a further chamber, i.e. they had an inlet or sucking opening in the melting chamber, while the outlet opening was directed towards this further chamber.

In order to be able to melt solid metal quickly in a melting chamber without risking too high a heat loss therein, it is known to pre-heat pigs which constitute the solid raw material. This, however, involves expenditure as to space, investment and energy. To achieve quick melting, often excessive temperatures in the melting chamber are accepted in practice. However, this results in a strong load of the lining of a furnace, of things built in and of the crucible itself which, in turn, reduces the service life.

Summary of the invention

It is an object of the present invention to achieve quick melting without stressing the melting chamber and its parts excessively.

For solving this problem, the applicant has made intensive investigations to better understand the mechanism of melting. From this, a recognitions resulted which led, in a first step, to the present invention. This recognition can be explained as follows.

In the art, as it was up to now, the melt, when introducing solid metal, mostly in the form of pigs, has a reduced temperature in the immediate surroundings of the solid metal still relative cold, partially down below the liquidus temperature, i.e. there will be an at least partial and, in any case, temporary solidification within this immediate surrounding. According to the melting interval of the alloy, a more or less thick solidified layer will form itself around the pig. Shape and extent of this partially solidifies zone are dependent on the geometry of the metal to be molten and upon the original temperature distribution. Roughly spoken,

partially solidified layers of different temperature will form around the solid metal body which, so to speak, wrap the solid body, thus preventing quick access of hot melt to these inner layers.

On the other hand, there is still a further effect: The duration of the partially solidified state and the volume subjected to partial solidification influence also the nature and amount of intermetallic compounds forming within the melt. This means that both avoiding freezing of the melt on the cold pig and quick melting thereof will essentially result to a large extent in avoiding formation of such, in principle undesirable, compounds and, therefore, to a better quality of the alloy. For the longer a certain volume is in a partially solidified state, the greater is the amount of such compounds forming during this time which contribute to an undesirable change of the alloy and to the formation of sump in the melting chamber and its crucible.

After these two recognitions had been gained, it was clear that increasing the melting rate was not only a question of productivity, but also of the ultimate quality. Now, investigations were carried further on.

It has been found that virtually no convective heat transfer occurred within the partially solidified zone around the metal to be molten. This is just what resulted in the phenomenon of a "wrap" of partially solidified metal around the solid metal. Within the partially solidified zone, convection exists only with a relative small temperature gradient, and the zone, as compared with the liquid melt, acts like a heat insulation. This explains also why the known agitators, used for other purposes anyway, could not change this condition, because they could only achieve a stream within a region of reduced viscosity, but not in the partially solidified zone of much higher viscosity.

This latter recognition of the influence of different viscosities to the agitation effect should, actually, prevent those skilled in the art from generating a stream of molten metal within the melting chamber for solving the problem. In so far, it is surprising when the inventors had found that the above objects can be achieved if the parameters of flow are selected in such a way that the melting time is, in maximum, half the melting time without such stream, under the condition that the temperature of said molten metal, when measured at at least one place in a distance of 5 mm in maximum from said solid metal introduced into said melting chamber, does not fall below said liquidus temperature.

This means that also in the case of the solution of the problem there are two inventive steps: First, the stream has to have a certain flow energy or strength as well as a certain flow rate in the region of the solid metal. This, in turn, means that a certain directional effect should be strived for, if one is not willing to generate an unusual strong stream, as has never been strived for nor has been carried out up to now, in the whole bath of melt. This partial characteristic means also that it is advantageous to provide the stream generation device as close as possible to the place where the solid metal is in the melt and/or that the flow energy and flow rate are selected in such a way that it is sufficient even with a stream generation device at a certain distance from the solid metal in order to achieve the criterion defined in the second partial characteristic, i.e. no reduction of temperature of the liquid or molten metal below liquidus temperature.

Tests have shown that such temperature criteria can relative easily be measure by probes and that, as will be explained below, it is even favorable within the scope of the present invention to provide at least one temperature sensor in a distance from the heating device of the melting chamber (in order not to falsify its measuring value) within the direc-

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tion of stream of the stream generation device, and particularly of a pump used as such a device. Therefore, the term "pump", as used in the context of the present specification should mean all devices that are able to generate a stream. The melting time can also easily be determined by measuring once with generating such a stream and once not.

As indicated above, it should be noted that the present invention is not limited to a certain type of stream generation device, although at least one pump (in the narrow sense of this term, or more of them, are preferred. Alternatively, an agitator could be used which generates an appropriately strong flow and, still better, an inductive agitator device, as is sometime used for continuous casting. With the latter device a stream directed towards the solid metal can easily be generated. On the other hand, such inductive agitators are expensive and energy consuming for which reason pumps (in the narrow sense of this term) are preferred.

In any case, comparison tests have shown that a one to ten times higher rate of melting the solid metal is possible using the method according to the present invention. This is even the case, if one considers the possibility of an entrainment of the solid metal in moving devices provided to this end, as they are used in ultrasonic cleaning, particularly of optical glass bodies performing an up and down movement (or alternatively a circular carrousel-like movement). Tests have shown that the formation of whirls generated necessarily is rather disadvantageous. A substantially laminar stream should be attempted, although will not be attained perfectly.

The measuring distance of 5 mm should, in fact, constitutes the admissible maximum. Although it will be understood that a certain acceleration of melting would be achieved even if at least an extreme thin layer is stripped from the "wrap" which surrounds the solid metal, but this would hardly be suffi-

cient, due to the above-mentioned function mechanism, to accelerate decisively the melting process. Preferably, however, the criterion in this connection, i.e. no reduction below the liquidus temperature, should be fulfilled already in a distance of 3 mm in maximum or even of about 1 mm.

A melting process in practice differs principally from the New Years custom of lead casting. For it has to be considered that the raw material supplied is subjected to various impurities which enter the bath during melting and should be separated there from pure molten metal. Part of these impurities will sink to the bottom due to their specific weight, another part, however, will form floating matter to float at the bath level surface. Therefore, it is preferred that the stream of molten metal has a main direction aiming away from the level of the bath and/or (e.g. depending on the composition and kind of impurities) away from the bottom of the melting chamber. In this way, intermixing of impurities having already segregated to the bath level or to the bottom is prevented and, thus, any deterioration of the metal's quality. A main component of the stream which aims away (in the above sense) will be best obtained if the stream of molten metal has a substantially horizontal main direction.

The above explanation relating to the function of melting shows also where, in some cases, a certain problem could reside when carrying out the method according to the present invention: a hot stream of liquid metal is directed towards an object that, due to its partially frozen state, has a significantly lower temperature. Of course, the effect will be obtained that the stream of melt too will cool down. Particularly in a case where the flow of melt is circulated several times, its melting effect can be clearly reduced. Therefore, it is advantageous if the stream of molten metal, having passed the solid metal, is directed against a heated surface of the melting chamber so as to be reheated again.

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In order to be able to control or monitor the temperature criteria mentioned above, it is advantageous if the temperature in the stream of melt is measured, particularly downstream the solid metal. This measurement, however, can also be used to control heating of the melting chamber, although there are numerous variations possible: the output signal of a temperature sensor could also be used to control the energy of the pump (flow rate and/or power) or a combination of such control possibilities would also be possible (e.g. first controlling o0ne of these parameters up to a certain limit and then the other parameter). It is preferred to control heating of the melting chamber in such a manner that the measured actual temperature is at least close to the nominal temperature, i.e. a non-liquidus temperature in a distance of 5 mm in maximum, or (preferred) 3 mm in maximum, or (still more preferred) about 1 mm.

Bearing the above explanation of the term "stream generation device" in mind, it is preferred if an apparatus according to the present invention for melting metal of a predetermined liquidus temperature, comprises a melting chamber and an associated heating device for heating the melt, and at least one pump having at least one inlet opening and at least one outlet opening and a pumping element between these openings for pumping said melt, wherein both the inlet opening and the outlet opening are in the melting chamber and below the level of the melt therein. Thus the at least one pump sucks the melt out of the bath and returns it via the outlet opening. When speaking of an "inlet opening" and an "outlet opening", it is to be understood that, if desired, a plurality of openings could be provided, e.g. several suction nozzles and/or jet nozzles around the solid pig provoking a suction stream and/or a jet stream. In this sense the term "opening" should be understood as meaning "at least one opening".

To provide a stream of melt aimed directly towards the solid metal, it is particularly advantageous if means are provided

which form a defined deposit area for the solid metal. With such an arrangement, it is then preferred that at least one of the openings of the pump(s) is directed towards this defined deposit area, particularly the outlet opening. This deposit area may be defined by a holding device receiving the solid metal and holding it in a distance from the bottom wall of the melting chamber. This has the advantage that the stream of melt can rinse around the solid metal from all sides, thus removing partially solidified or not completely molten layers of it into the bath of melt for melting them completely.

One criterion according to the invention is that the stream of melt has such a flow energy and flow rate in the region of the solid metal that a certain temperature condition id fulfilled. However, with different metals and different melting temperatures, this may be very different. Therefore, it is favorable if the pump is of the type having a variable number of revolutions which may be varied by a manual or automatic control unit.

In the preferred case of an automatic control unit, at least one sensor may be suitably provided for sensing at least one of the parameters of the temperature of said melt and the level of said melt. This sensor means will then provide a corresponding output signal. For example, the sensor may be a level sensor which is coupled to the automatic control unit, while the output of this automatic control unit is coupled to the pump to control its number of revolutions. Other sensors used in the context of this invention may be a sensor for the size of a pig, for the flow rate (which is quite different with different viscosities), a "barrier" sensor which senses whether a pig has just been introduced into the melting chamber (then causing a higher number of revolutions), optionally a timer (which reduces the numbers of revolution a time after the solid metal has been introduced and one can suppose that it has been molten at least in part), or a sensor for the

temperature of a heated wall of the melting chamber (because the heat introduced should reheat the stream having passed the pig, in a preferred embodiment). For example several ones of these parameters could be input into a neuronal network (or a fuzzy control) weighting them for providing a corresponding control signal, particularly for controlling the number of revolutions of the pump, but alternatively or in addition of the heating power and so on. From the above, it is apparent that it is advantageous if at least one of the sensors is a temperature sensor.

Above, an aimed stream towards the solid metal has been mentioned which can easily be achieved if a defined deposit area for the solid metal is provided. However, regardless whether such a deposit area is provided or not, an aimed stream may also be obtained by providing a guiding arrangement for guiding the flow of melt in a predetermined desired direction. Such a guiding arrangement may then be used to direct the stream of melt in a direction as explained above, i.e. passing the solid metal for removing partially solidified layers from its outer surface, on the one hand, but preferably away from the level of the bath and/or away from the bottom and/or against a heated wall to achieve reheating of the melt after cooling by the solid and partially solidified metal.

If now a pump (in the narrow sense of this term) is used for generating the stream of melt, this pump may be of any kind. It can, for example have its pumping element (rotor or plunger or injector) outside the melt so that the melt is supplied via a tube whose inlet opening is in the melt, while another tube or pipe returns then the melt into the melting chamber through the outlet opening. However, this would result in undesirable cooling, for which reason it is preferred if not only the inlet opening and the outlet opening are in the melting chamber and below its melt level, but also the pumping element.

Brief description of the drawings

Further details of the invention will become apparent from the following description of embodiments schematically shown in the drawings, in which

Fig. 1 is a cross-sectional view if a melting furnace according to the present invention;

Fig. 2 is a cross-section along the line II-II of Fig. 1, but showing a modified form of a holding stand for receiving a pig and of its guiding surfaces; and

Fig. 3 a plan view, corresponding to arrow III of Fig. 1, of a further modification.

Detailed description of the drawings

Fig. 1 shows a two-chamber-furnace 1 comprising a crucible 3 inserted into a furnace space. The furnace 1 is subdivided along a plane P into a melting chamber 4 and an extraction chamber 5. A shielding partition or bulkhead 6 and a further transverse wall 7 below serve for this subdivision. The transverse wall 7 has optionally a narrow opening 8 for enabling a sump or bottom sludge to slide over the inclined crucible bottom 9 towards the melting chamber 4 so as to avoid contamination of the melt in the extraction chamber 5. An opening 10 serves the communication of the melt from one chamber to the other. It will be understood that this construction is only given by way of example and that the furnace may have any design desired.

Within the furnace space 2, a heating device 11 merely schematically indicated is provided as is known *per se*. This heating device 11 may be of any kind desired, for example it may be formed by the pipes of a gas burner or by inductive heating coils. This heating device 11, in the embodiment shown, does not only heat the bottom 9 of the crucible 3, but also at least one lateral wall 12. The upper side of the cru-

cible is covered by a crucible cover plate 13 in order to avoid heat losses and/or the access of oxygen to the chambers 4 and 5. The crucible cover plate 13 may comprise connection pipes 14 of introducing an inert gas (such as argon) or a protective gas (e.g. nitrogen which may form magnesium nitride with magnesium) to cover the level surface of the melt with the inert or protective gas.

All these parts are of conventional nature and can appropriately be modified, if necessary. In the melting chamber 4 is a holding stand 15 for depositing pigs 16, i.e. blocks of solid metal, which are introduced into the melting chamber 4. By this holding stand 15, pigs 16 are held in a distance from the bottom wall 9 so that the melt surrounds the respective pig from all sides and transfers heat for melting it.

In accordance with the present invention, a flow or stream generating device, in the present embodiment a pump 18, is provided. This pump, in the embodiment shown, has a pump tube 19 in which a shaft extending along an axis A is supported which drives a pump rotor 20 (merely shown in dotted lines) at its end. This pump rotor 20 sucks melt through suction or inlet openings 21 located within the melting chamber and below the ordinary level of the melt bath (which is mostly defined by the level at which the heating device 11 terminates). In this way, the pump rotor 21 generates a suction stream corresponding to arrows a1. The pump rotor 20 is driven by a motor 24 at the top of the pump 18 which has, preferably, a variable number of revolutions.

The lower end of the pump tube 19 terminates in an outlet opening 22 also being situated within the melting chamber 4 and, preferably, below the level of the melt bath. The outlet opening 22 is preferably directed towards that area where the pigs 16 are accommodated at the holding stand 15 so that a direction of flow or stream corresponding to arrows a2 will form. Certainly, it would be conceivable to orient the outlet

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opening 22 in a different direction so that the stream of melt emerging from it reaches the pigs 16, so to speak, according to the "billiard principle", i.e. indirectly, but this will, in general, be more energy consuming. Preferably, a guiding sheet 23 is provided above the suction or inlet openings 21 to avoid that suction has an effect to the level surface of the bath. A similar guiding sheet could be provided below the suction openings 21 to avoid a "short circuit effect" directly to the suction openings 21 of the melt stream exiting the outlet opening 22.

Furthermore, it should be noted that any other stream generation device instead of an ordinary pump 18 could be used, such as a mechanical agitator or an inductive agitator accommodated, for example, outside the crucible 3 or in its lining, but, in general, the efficiency will be less. Likewise, the pumping element, in this embodiment the pump rotor 20, could be arranged outside the crucible 3, if only (and at least) the inlet and outlet openings 21 and 22 are within the melting chamber 4, but this would involve that the pumping element is at a lower temperature level which is less desired.

The stream a2 is, as shown, directed towards that area where the pigs 16 are situated, i.e. slightly above the holding stand 15. It would be conceivable to arrange it so that the suction stream a1 provided for a intensive rinsing of the pigs 16, but it is preferred, if this is done by the pressure stream a2. The number of revolutions of the rotor 20, the proximity of the outlet opening 22 to the pigs 16 and the flow energy provided by the motor 24 are selected in such a manner that the melting time is, in maximum, half the melting time without said stream, i.e. with the pump 18 switched off, under the condition that the temperature of the molten metal, when measured at at least one place in a distance of 5 mm in maximum from said solid metal 16 introduced into said melting

chamber, does not fall below said liquidus temperature. The reason for this measure has already been discussed above.

Advantageously, at least one temperature sensor 25 will be mounted on the crucible cover plate 13 and will suitably be arranged in a distance D from the pigs 16, but also in such a distance from the lateral wall 12 that its heating device 11 substantially does not affect its measuring result. Distance D should conveniently be chosen 0.5 cm in maximum, but preferably somewhat less, e.g. 0.3 cm in maximum. Since the stream a2 will be cooled when passing the cold pig 16, its temperature will be the lowest at the end of the pig 16, i.e. in the region of the lower tip of the temperature sensor 25. Therefore, if the temperature measured at this point is above the liquidus temperature, one can suppose that at least the greater part of the surface of the pig 16, in a distance of 0.5 cm in maximum, is above the liquidus temperature.

Therefore, it is advantageous to monitor this temperature by at least one temperature sensor 25. If the temperature measured there is too low, one could change the parameters of flow, i.e. for example, the pump 18 and its outlet opening 22 is approached to the pig 16. As an alternative or in addition, the temperature of the heating device 11 may be raised. The latter is particularly effective, because stream a2, as shown, is directed also towards the heated lateral wall 12 so that it flows, after cooling by the solid metal of the pig 16, along the lateral wall 12, thus gaining in temperature anew. However, the arrangement can be different, because it would also be possible to direct the stream a2 towards top of the pig 16, i.e. from above, so that the stream, having passed the solid metal 16, touches the heated bottom wall 9 to be reheated anew. Combinations of both stream directions would also be possible.

However, it is preferred if, as mentioned above, the number of revolutions of the pump 18 (or the pump frequency of a

plunger pump) can be adjusted so that the flow rate of the stream can be controlled or influenced. This adjustment may, of course, be made manually, but it is more advantageous if a control circuit, e.g. including a processor 26, such as a micro-processor, which is coupled with at least one temperature sensor 25 to receive its output signal. If a plurality of temperature sensors are provided, the processor 26 may weight the output signals thereof, the weight of the signals being, for example, in the order of the stream direction of stream a2 so that the signal of the temperature sensor 25 situated at the end has the highest weight, whereas the signals of sensors situated before have a lower weight. Weighting, as has been mentioned before, can be done by installing a neuronal or a fuzzy network in the processor 26.

In the present embodiment, the processor 26 has two outputs. On the one hand it is coupled to the motor 24 (or a final control stage not shown) for varying the number of revolutions of the pump 18. On the other hand, an output line is coupled to a final control stage 27 for adjusting the heating power of the heating device 11. For example, control in cascade would be conceivable where first the number of revolutions of the pump 18 up to a maximum (which may optionally be set) and, if the temperature according to the output signal of the temperature sensor 25 is still too low, the heating power of the heating device 11 is increased. Furthermore, a level sensor 32 (here symbolized as an acoustic level sensor operating according to the echo principle, such as an ultrasound sensor, which, however, may be of any kind) which controls the number of revolutions of the pump 18 through the processor 26.

If the stream generated by the pump 18 is to circulate around the solid metal 16, it is advantageous to provide guiding surfaces, besides the guiding surface 23 on the pump, also in the region of the pig 16 in order to ensure that the (almost laminar, but whirls not being fully excluded) stream passes

really along the surface of the pig 16 and against the heated wall 12. To this end, it is favorable if, for example, the holding stand 15 is provided with appropriate guiding surfaces 28, as illustrated in the embodiment of Fig. 2. It should be noted, however, that the present invention is not restricted to stands sitting on the bottom 9, but also basket-like stands hanging from the crucible cover plate 13 could be used.

In the embodiment of Fig. 2, the pig 16 is on vertical guiding sheets 28′ which form flow channels 29 between one another whereby the solid metal of the pig 16 is "rinsed" or supplied with hot melt from below when the pump 18 is operating. The output opening 22 of the pump 18, in this embodiment, is oval in cross-section so that the pig 16 is passed by hot melt on its sides too. However, the output opening 22 is far enough from the pig 16 that the exiting stream reaches also the flow channels 29. It will be understood that such an arrangement having flow channels that are open tworads the pig 16 could also be provided at other surfaces of the pig 16.

Fig. 3, in turn, shows an embodiment where the surfaces of the guiding sheets 28" are parallel to the surfaces of the pig 16. Accordingly, the stream a2 enters flow channels 29a, 29b and 29c formed between three sheet metal guidances 28" parallel to each other. In the course of the path of flow, the stream of melt may cool down at the solid metal 16. In order to guide new hot melt to the outer surface of the metal 16 to be molten, the flow channel 29a is narrowed to a small opening 31, and the middle flow channel 29b carrying still hotter melt is directed to the pig 16. At the same time, the outermost channel 29c is deviated into a middle path where previously the flow channel 29b had been. In order to introduce simultaneously new hot melt a kind of injector opening 30 may be provided, leading into the flow channel 29c. After a further third of the way, the outer flow channel 29c is di-

rected towards the outer surface of the pg 16, an opening 31 being provided for allowing the melt conveyed through the channel 29b to pass through. These narrowings provoke also an increased flow rate which contributes to faster melting.

Although this arrangement has been shown in a plan view, it will be understood that similar arrangements could either be provided for all outer surfaces of the pig 16 or only a part of them. It would also be conceivable to convey the stream of the respective channel passing along the outer surface of the pig 16, such as of channel 29a, away in upward or downward direction or laterally. In any case, it is essential that hot melt is directed to the outer surface of the pig 16 again and again over the length of the pig 16 either by utilizing an injector effect or in another way. For in each case a direction is associated to the stream a2 by means of the guiding devices 28, 28′, 28″ which is directed away from the level surface of the melt bath and/or from the bottom 9 of the melting chamber 4.

Numerous modifications are conceivable within the scope of the present invention; for example the holding stand 15 could be shiftable towards the output opening 22 or away from it. Moreover, more than one pump could be used or, alternatively or in addition, a plurality of outlet openings 22 and/or inlet openings 21 around the pig 16. Furthermore, the holding stand 15 may be dimensioned so as to support more than two pigs 16. As has been mentioned above, the nature of the pump (or device having a pumping or entraining effect) is not decisive, for a plunger pump having a piston as a pumping element could be used instead of a pump, as illustrated, having a rotor as a pumping element (although the latter is preferred). Moreover, it is certainly favorable if the pig is lying in the melting chamber, but the principle of the invention would, of course, also work providing vertically standing pigs (where the stream of melt is either vertical or horizontal or both).

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WHAT IS CLAIMED IS:

1. A method of melting metal of a predetermined liquidus temperature in a heated melting chamber having a bottom, the method comprising the steps of:
providing a bath of said metal in molten state in said melting chamber, said bath having a certain level and a temperature above said liquidus temperature;
introducing solid metal into said bath so as to melt said solid metal during a melting time;
generating a stream of molten metal in said melting chamber, said stream having certain parameters of flow including flow energy and flow rate;
choosing said parameters of flow such that the melting time is, in maximum, half the melting time without said stream under the condition that the temperature of said molten metal, when measured at at least one place in a distance of 5 mm in maximum from said solid metal introduced into said melting chamber, does not fall below said liquidus temperature.

2. Method as claimed in claim 1, wherein said metal is a non-iron metal.

3. Method as claimed in claim 2, wherein said non-iron metal is magnesium.

4. Method as claimed in claim 1, wherein said distance amounts to 3 mm in maximum.

5. Method as claimed in claim 4, wherein said distance amounts to about 1 mm.

6. Method as claimed in claim 1, wherein said condition is fulfilled at more than one place in said distance.

7. Method as claimed in claim 1, wherein said stream of molten metal has a main direction aiming away from said level of said bath.

8. Method as claimed in claim 1, wherein said stream of molten metal has a main direction aiming away from said bottom of said melting chamber.

9. Method as claimed in claim 1, wherein said stream of molten metal has a substantially horizontal main direction.

10. Method as claimed in claim 1, wherein said stream of molten metal is directed towards said solid metal.

11. Method as claimed in claim 10, wherein said stream of molten metal, having passed said solid metal, is directed against a heated surface of said melting chamber.

12. Method as claimed in claim 1, wherein said at least one place is within said stream of molten metal.

13. Method as claimed in claim 12, wherein said at least one place is downstream said solid metal in said melting chamber.

14. Method as claimed in claim 1, wherein said temperature is measured to control and maintain said condition.

15. Method as claimed in claim 1, wherein said temperature is measured to control heating of said melting chamber.

16. An apparatus for melting metal of a predetermined liquidus temperature, comprising
a melting chamber for receiving said metal in a solid state, said melting chamber having lateral walls and a bottom wall;

heating means for heating at least one of said walls for providing a melt of said metal within said melting chamber up to a certain level;

pump means having at least one inlet opening and at least one outlet opening and a pumping element between said openings for pumping said melt, said inlet opening and said outlet opening being both in said melting chamber and below said level.

17. Apparatus as claimed in claim 16,wherein said pump means are of the type having a variable number of revolutions, said pump means further including control means for varying said number of revolutions.

18. Apparatus as claimed in claim 16,further comprising wall means forming an extraction chamber, and transfer means for transferring melt from said melting chamber into said extraction chamber.

19. Apparatus as claimed in claim 16, wherein said transfer means comprise communication means between said melting chamber and said extraction chamber.

20. Apparatus as claimed in claim 16, wherein not only said inlet opening and said outlet opening are in said melting chamber and below said level, but also said pumping element.

21. An apparatus for melting metal of a predetermined liquidus temperature, comprising

a melting chamber for receiving said metal in a solid state, said melting chamber having lateral walls and a bottom wall;

heating means for heating at least one of said walls for providing a melt of said metal within said melting chamber up to a certain level;

pump means having at least one inlet opening and at least one outlet opening for pumping said melt, said inlet opening and said outlet opening being both in said melting chamber and below said level; and

means forming a defined deposit area for said solid metal.

22. Apparatus as claimed in claim 21, wherein at least one of said openings of said pump means is directed towards said means forming a defined deposit area.

23. Apparatus as claimed in claim 22, wherein it at least said outlet opening that is directed towards said means forming a defined deposit area.

24. Apparatus as claimed in claim 21,wherein said means forming a defined deposit area comprise holding means for receiving said solid metal and holding it in a distance from said bottom wall.

25. Apparatus as claimed in claim 21, further comprising at least one temperature sensor arranged below said level and in a distance from both said heating means and said means forming a defined deposit area.

26. Apparatus as claimed in claim 25, wherein said distance amounts to 5 mm in maximum.

27. Apparatus as claimed in claim 25, wherein said distance amounts to 3 mm in maximum.

28. Apparatus as claimed in claim 25, wherein said distance amounts to about 1 mm.

29. An apparatus for melting metal of a predetermined liquidus temperature, comprising

a melting chamber for receiving said metal in a solid state, said melting chamber having lateral walls and a bottom wall;

heating means for heating at least one of said walls for providing a melt of said metal within said melting chamber up to a certain level;

pump means having at least one inlet opening and at least one outlet opening for pumping said melt, said inlet opening and said outlet opening being both in said melting chamber and below said level; and

sensor means for sensing at least one of the parameters of the temperature of said melt and the level of said melt, said sensor means providing an output signal.

30. Apparatus as claimed in claim 29, wherein said sensor means comprise at least one temperature sensor arranged in a distance from said heating means.

31. An apparatus for melting metal of a predetermined liquidus temperature, comprising

a melting chamber for receiving said metal in a solid state, said melting chamber having lateral walls and a bottom wall;

heating means for heating at least one of said walls for providing a melt of said metal within said melting chamber up to a certain level;

pump means having at least one inlet opening and at least one outlet opening for pumping said melt, said inlet opening and said outlet opening being both in said melting chamber and below said level; and

sensor means for sensing at least one of the parameters of the temperature of said melt and the level of said melt, said sensor means providing an output signal; and

automatic control means receiving said output signal and providing at least one control signal at their output for controlling at least one of the parameters includ-

ing flow energy, flow rate, flow temperature and said level.

32. Apparatus as claimed in claim 31, wherein said sensor means comprise at least one temperature sensor, said output of said automatic control means being coupled to said heating means for controlling their power.

33. Apparatus as claimed in claim 31, wherein said sensor means comprise a level sensor, the output of said automatic control means being coupled to said pump means to control them.

34. An apparatus for melting metal of a predetermined liquidus temperature, comprising

a melting chamber for receiving said metal in a solid state, said melting chamber having lateral walls and a bottom wall;

heating means for heating at least one of said walls for providing a melt of said metal within said melting chamber up to a certain level;

pump means having at least one inlet opening and at least one outlet opening for pumping said melt, said inlet opening and said outlet opening being both in said melting chamber and below said level to generate a flow of melt; and

guiding means for guiding said flow of melt in a predetermined direction.

35. Apparatus as claimed in claim 34, wherein said guiding means are formed and arranged to direct said flow of melt away from said level.

36. Apparatus as claimed in claim 34, wherein said guiding means are formed and arranged to direct said flow of melt away from said bottom wall.

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37. Apparatus as claimed in claim 34, wherein said guiding means are formed and arranged to direct said flow of melt in a substantially horizontal main direction.

38. Apparatus as claimed in claim 34, wherein said guiding means are formed and arranged to direct said flow of melt first to said solid metal and then against a heated wall of said melting chamber.

39. Apparatus as claimed in claim 34, wherein said guiding means are formed at least in part on said pump means.

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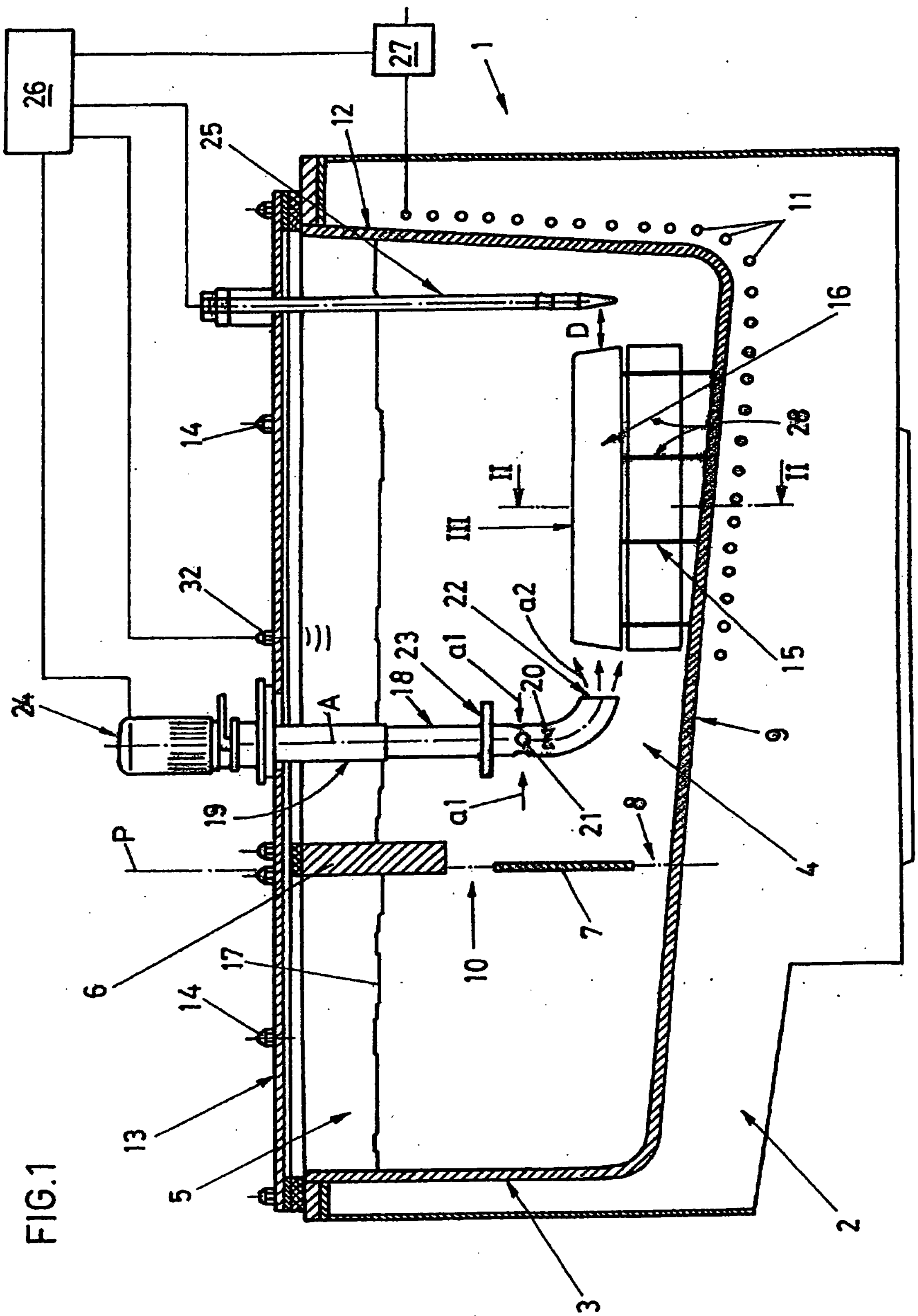

FIG.1

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FIG.2

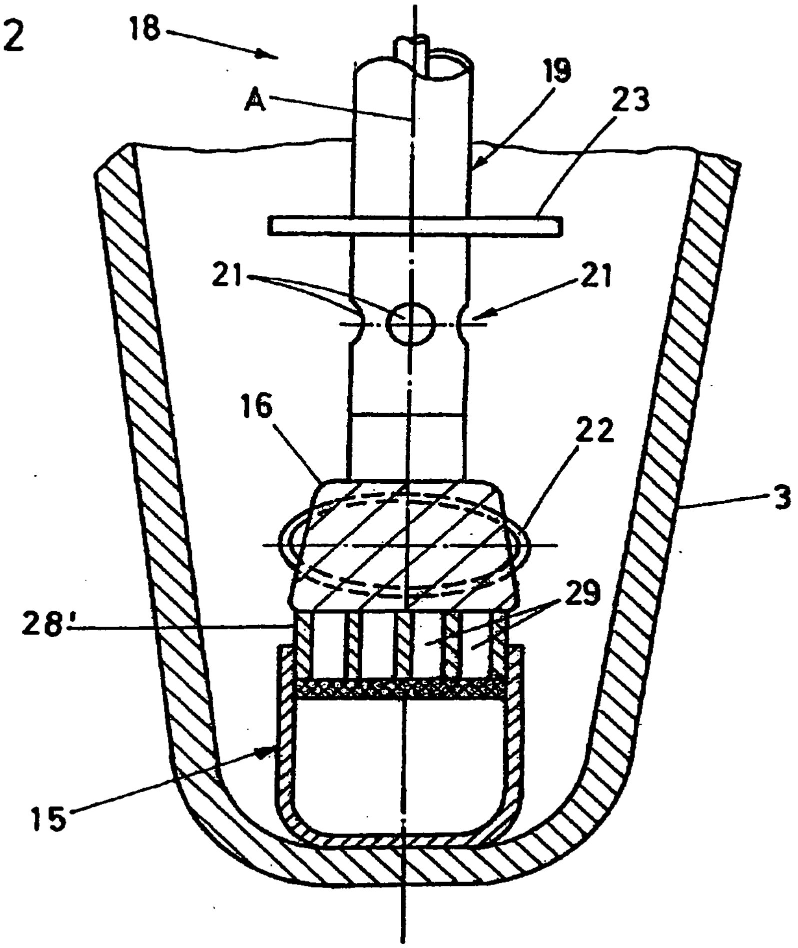

FIG.3